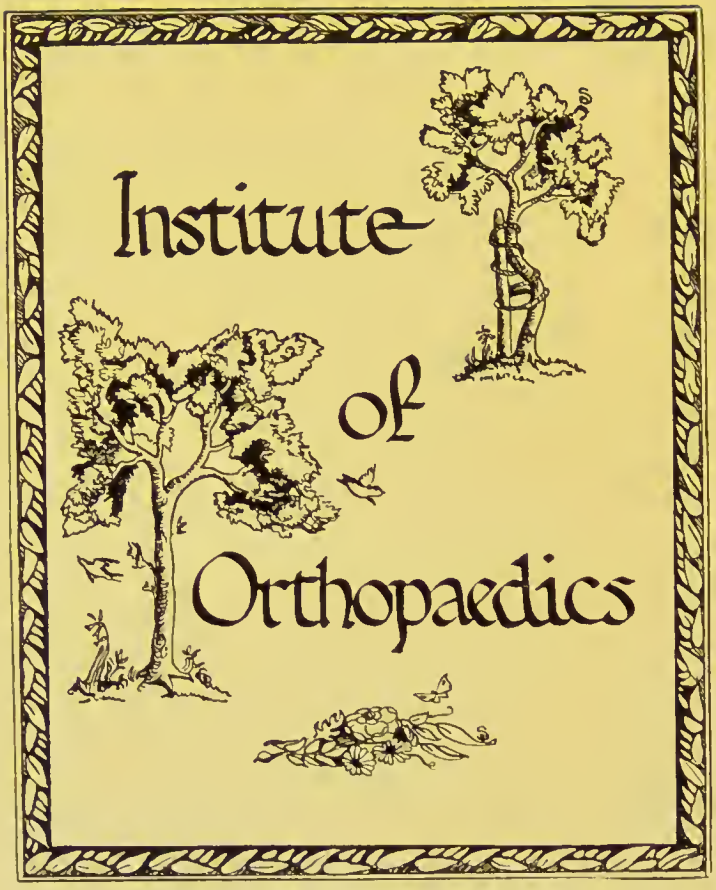

E. C.

Jan. 1912

DISEASE IN BONE AND ITS DETECTION BY THE *X*-RAYS

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DISEASE IN BONE

And its Detection by the X-Rays

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WITH ILLUSTRATIONS

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PREFACE

THIS small work constitutes an attempt to record facts which radiographic experience, extending over some fourteen years, has made me regard as fundamental in diagnosis.

They are facts which are not generally known, or I venture to think that surgeons would make more use of the *X*-rays, and not merely relegate them to the detection of coarse and obvious lesions.

So many diseases, clinically alike, are radiographically different—as instances, (1) Tubercle and osteo-arthritis, (2) Malignant disease and chronic inflammatory trouble in the shafts of long bones. Several examples have come to my notice in which mistakes made in these conditions might have been avoided by the skilful use of the *X*-rays. I would lay emphasis on the word "skilful," for the prevalent method of getting a patient photographed with *X*-rays by anyone in possession of an *X*-ray apparatus is, in my opinion, worse than having a patient's chest examined by someone whose only qualification to office is the possession of a stethoscope.

The absurdity in this latter case is too apparent to need discussion, and yet, in connection with the

former where the diagnostic instrument involved is infinitely more complex and the initial difficulties much greater, we are seldom vouchsafed more information than that the "*X*-rays did not show, etc., etc." We most of us only "see the things we are taught to see," and I venture to predict that in years to come we shall marvel at the very obvious pathological conditions that we are missing to-day for want of looking for them.

I would further predict that the examination for varying densities in bone will become a routine practice in surgical if not also in medical diagnosis. I have not seen attention called to the various forms of thinning which are treated of in the following pages and which accompany many chronic diseases. Among such I would put alcoholism. No doubt there are many more, and I hope to be able to add to the list at a later date; but the difficulties are very great from a technical point of view. The vagaries of the tube ape the conditions themselves, and considering one is dealing with millionths of an atmosphere it is scarcely to be wondered at. To keep the source of *X*-rays steady is like balancing an egg on the edge of a sword. The equilibrium is of a most unstable nature. These remarks apply to the newer forms of *X*-ray apparatus, such as the "Snook," which at their best are so much better than the older type of coil and interrupter, but which involve more risk to tubes and greater skill in management.

In selecting radiograms I have endeavoured to obtain those which I consider typical, and such as represent the usual work of a well-equipped *X*-ray department, and none have been printed for their photographic excellence. Opinions differ as to what is excellence in this respect. The less an individual has studied the subject the more he favours the black and white picture. Conversely, the better informed he is the less he strives after contrast and the more value he attaches to detail and the faithful reproduction of the relative densities of the tissues he is dealing with. It would seem reasonable to suppose that those radiograms are best which most faithfully represent the conditions which are present, and to use artifice to obtain a brilliant photograph of a tubercular joint seems to me to be attempting a piece of childish self-deception. This is where the layman has the advantage of the medical man because he so often takes "clearer" photographs. These facts may seem elemental, but they are apparently common knowledge only to those who work with the rays. The illustrations in the following pages are from purely unfaked photographs, and the blocks are true reproductions of these.

On account of the number of these blocks I have adopted a large type and wide margin, thereby ensuring that illustrations shall be near the passages that refer to them.

It will be noticed that joint disease is rather mixed

up with bone disease, but my excuse is that the radiographer does not, strictly speaking, see the joint surfaces, and bases his conclusions on the adjacent bone tissue.

No attempt has been made to completely cover the somewhat vast ground suggested by the title of this book, and many common conditions are conspicuous by their absence. In some cases this is due to want of sufficient evidence, in others to the fact that the *X*-rays are not as suitable as other clinical methods of examination. One omission I must just mention—syphilitic disease. About this I hope, later, to be able to give some helpful notes, but at present they are not ripe for publication.

I would like to take this opportunity of thanking many friends who have helped me directly or indirectly in the compilation of these notes. To my colleagues, Drs. Morton and Jordan, I am indebted for many kindnesses, and to the staff of Guy's Hospital I owe more than I can acknowledge here, but for nothing am I more grateful than their attitude towards the whole subject of *X*-ray work. In my opinion it has raised radiography from a branch of photography to a branch of practical medicine. As a pioneer I might have had the rough time pioneers look for, but my way has been considerably smoothed by their generous encouragement.

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DISEASE IN BONES

INTRODUCTORY REMARKS

Those changes which take place in bone, whereby its condition is altered from one of health to disease, are accompanied by variations in opacity to *X*-rays. A decrease in density due to absorption of mineral matter is a much earlier and more quickly visible change than increase of density caused by extra deposition of mineral matter or new bony growth.

From which it may be gathered that generally speaking acute bone disease is made evident by increase of transparency, and chronic disease by increase of opacity.

Certain pathological conditions in bone are of course manifested by alteration of contour when examined by the *X*-rays, but even these are usually accompanied by changes in the opacity of the bony substance. It is therefore mainly to changes in density that one must look for help in the diagnosis of disease in bone.

Normal variations in bone density.

Normal variations in bone density (meaning by density opacity to the *X*-rays) need careful consideration at the outset, for unless the observer makes himself familiar with these he may be led into much confusion. Bones increase in their density from fœtal to adult life (or perhaps it would be more correct to say until the epiphyses are united), and remain constant after this. In old age the bones may appear denser, but this is mainly due to the lessened opacity of the surrounding tissues. In like manner thin people will seem to have denser bones than stout ones. Constant examination of the human subject will familiarise the observer with these normal appearances and enable him to detect the abnormal more easily.

Old age.

Variations due to quality of *X*-rays.

Mention must be made of another variation in the apparent density, due solely to the *X*-ray tube. Tubes in which the vacuum is not very pronounced, technically known as low tubes, produce a very black image of the bones both on screen and photographic plate. On the photograph, although the contrast between bone and background is very great and the picture on this account rather attractive to the person who likes everything "very clear," it will be noticed that detail is mostly missing ; the effect is more that of a silhouette than a photograph (Fig. 1).

Low tubes.

High tubes.

Tubes of the opposite variety, *i.e.*, the high tubes, those in which the residual gas has been

reduced to a minimum compatible with the passing of an electric current (N.B.—A perfect vacuum is impenetrable by electricity), give a

FIG. 1.—Specimen of apparently good radiogram of knee-joint, which in reality would be useless for demonstrating any but very gross lesions. It is quite unsuitable for observing atrophic changes. Compare this with Figs. 28 and 33.

faint grey image upon screen and plate. The want of contrast between background and bone makes the picture appear weak upon casual examination, but close observation will show a vast

fund of detail which may be of the utmost value in detecting disease. Generally speaking, a tube inclined to be high will be of more value than one of the opposite variety, but it is the part of the radiographer to suit his tube to his patient, and the tube will therefore hereafter be considered as a fixed quantity in discussing the *X*-rays in relation to bone disease.

Importance of limiting size of picture.

Before leaving the technique there is one other fundamental matter to be mentioned. If an unshielded tube is used for screening or radiographing, a much larger picture is produced, always supposing the size of the plate to be unlimited. Thus it is quite possible to get a leg showing knee and ankle joint on one photograph, but this is only done at the expense of definition. The *X*-rays, being rapidly divergent, must of necessity distort an image as it approaches the margins of the plate; therefore in the above case both knee and ankle will be distorted. This should be borne in mind when attempt is made to get both hips upon one plate. The best rays are wasted in the middle of the plate, and it is usually much better to take two small plates so arranged that the centres of the illumination fall about the position of the acetabula. Then again an unshielded tube, like an unstopped photographic lens, is the cause of much distortion and fogging, and the use of a diaphragm as small as the subject will allow is advisable in every case.

Importance of using shield or diaphragm.

If it is essential to take a large plate, that is, get a large portion of the body into one picture, this is best done by increasing the distance of tube from plate and still using the diaphragm. Such a method makes exposure very long unless apparatus such as the "Snook" is available.

It should be a fairly easy matter for anyone acquainted with *X*-ray appearances of bone to recognise a departure from the normal. In the investigation of bone disease I would lay greater stress upon the advisability of *X*-ray photography as compared with screening than in any other branch of *X*-ray diagnosis. The roughness of the fluorescent screen, which seldom presents any hindrance to diagnostic work in a general way, may do so in the case of bone substance by effectually obliterating the definition of the cancellous tissue. The photographic film is much better suited to this work on account of its fine grain.

Advisability of photography.

The screen, however, is of paramount importance during the taking of the radiogram, to enable the radiographer to select the correct view and adjust the vacuum of his tube.

Use of screen.

Passing on to the subject of abnormal variation of density in bone, it will be necessary to consider conditions which, not being actually pathological, are yet often precursors or concomitants of disease.

Precursors of disease which affect bone.

Malnutrition in the human subject is accom-

panied by atrophic changes in bone, and these are evidenced by increase in transparency to the Röntgen Rays.

Mal-nutrition. Malnutrition being more rife among the lower classes than the well-to-do, it follows that hospital patients very frequently show this atrophic change, and their bones are more difficult to discern than those of the well-nurtured individual, and it is notable how much more difficult it often is to distinguish the outlines of a fracture in such a case when much extravasation of blood at the seat of fracture has increased the *X*-ray density of the surrounding tissues. This malnutrition is well marked, as would be expected, in many cases of rickets, but as the patient recovers in this disease Rachitis. the mineral matter is reinstated, and a rachitic deformity therefore is not invariably accompanied by a want of density. As a diagnostic factor this thinning of the mineral matter is not of much value in rickets compared with such easily ascertained facts as exaggeration in the normal curves of the long bones, the secondary curves and enlargements at the line of junction of diaphysis and epiphysis. However, as a guide to the progress of a case of rachitis the rays may be helpfully used for observing variations of density (Fig. 2).

Anæmia. Anæmia, from any cause of prolonged duration, will affect the transparency of the bones as will any disease in which malnutrition of the body generally is a prominent feature. An interesting and per-

haps unlooked for cause of loss of *X*-ray density is found in the case of rest or disuse of the bones of the limbs. This is a matter of common observation

FIG. 2.—Genu Valgum. Typical rachitic bones.

in any *X*-ray clinique. A bone set at rest after fracture is a good example of this condition. A few days are sufficient to bring about a degree of absorption of mineral matter capable of

Bones at rest.

demonstration. I am unable to say that treatment of fracture by massage or hyperæmia has any influence upon this appearance, but would expect to find that atrophic changes were less marked if not entirely absent.

Mal-union causing atrophic change.

Cases in which union of a fracture has not taken place show marked diminution in density—that is, when they have arrived at the stage at which efforts at repair have been discontinued. Naturally, previous to this, while an excess of callus is being thrown out in a vain endeavour to accomplish fixation of the fragments, an increase of density may be visible merely from the excess of bony tissues about the seat of the fracture. A fractured femur which had resisted all the efforts of Nature and the surgeon to become united showed this thinning to such an extent that the bone was scarcely visible in the radiogram.

Atrophic change in alcoholism.

A variety of thinning of bone in an *X*-ray sense is to be found in the case of the chronic alcoholic. It is a common occurrence to see in the bones of these people a uniform atrophic appearance. Fractures in these bones are disastrous in their magnitude, being accompanied by much comminution and crumbling (Fig. 3). They also are slow to unite and unfit for operative measures. I cannot help thinking in this connection that before bone operations the surgeon would be well advised to have the quality of the bone tested in this way.

Testing bone before operation.

FIG. 3.—Bad fracture in atrophic bone (probably alcoholic).

Callus.

The subject of callus formation may be fittingly considered here.

There is much variation in the *X*-ray appearance of callus, and as callus is only made visible by the deposition of mineral matter in its substance, these variations are mainly due to some abnormality in the manner of this deposition.

It is a most fortunate fact that early callus is entirely transparent to the *X*-rays; otherwise we should not be able to judge the nature and extent of a bony lesion except just after its occurrence. As it is, for many weeks we see the exact outline of a fracture, and sometimes the deposit of mineral matter is delayed for months.

Average time of appearance of callus.

It would be difficult to fix an average time at which callus becomes visible to *X*-rays; perhaps three to eight weeks is the normal fluctuation.

Occasionally abnormal formation of callus is met with; for example, in connection with an ununited fracture a great superabundance of callus may be present, evidently an effort on the part of Nature to obtain the desired fixation of fragments at any price.

A small, clean fracture unaccompanied by displacement conversely will show a minimum of callus, and whatever is formed is quickly absorbed as union is effected. The more nearly the fractured bone is restored to its original shape and the more complete the fixation of this position the less callus will be formed, and the less mineralised will

this callus be. In fracture successfully treated by open operation, where perfect position and fixation has been accomplished, it is unusual to get any *X*-ray evidence of callus. For many years I have had the opportunity of examining nearly all the cases of fracture treated surgically by Mr. Arbuthnot Lane, and the entire absence of callus is a constant feature. In cases of old fracture and bad compound fractures callus is usually evident, but in very much smaller quantity than when treated by other methods. It would seem reasonable to suppose that the rapid convalescence and restoration to complete mechanical activity which is so noticeable in these cases is due partly to the elimination of energy expenditure necessary for the formation and mineralisation of large masses of callus ; and to the absence of interference of soft parts around the seat of fracture due to the pressure of a large unaccommodating mass of bony material.

Mr. Lane's cases of surgically treated fractures.

An example which Mr. Arbuthnot Lane has kindly allowed me to reproduce will here illustrate the absence of callus in a typical case (Fig. 4).

A curious abnormality in callus formation is shown in Fig. 5, and the explanation is not apparent. I have seen such a condition before but very rarely. The curious arrangement of the mineral deposits is noticeable and the history of definite fracture is missing. Whether the

Abnormal callus.

FIG. 4.—Typical example of Mr. Arbuthnot Lane's method of treating fractures surgically. The entire absence of callus is noticeable.

fracture was devoid of clinical signs and the patient continued to use these bones despite the injury, and thus an abnormal callus was caused to form, I

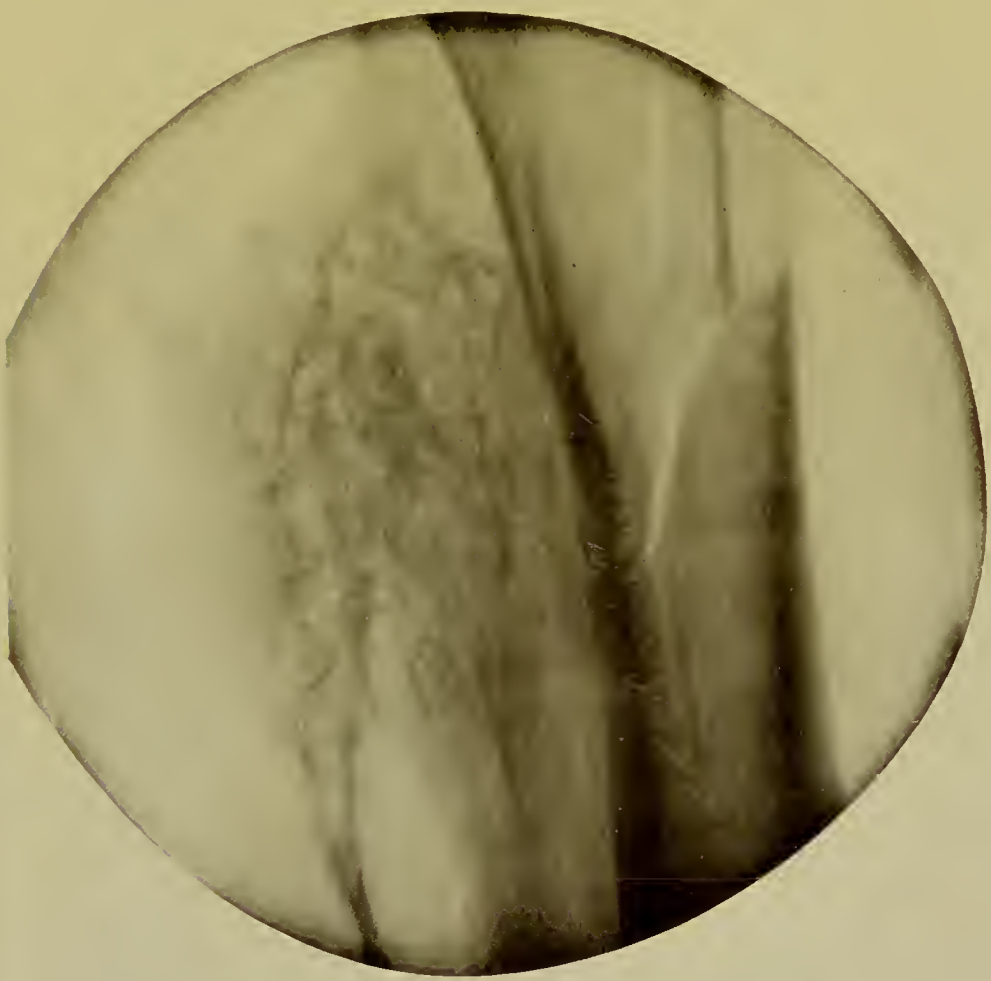

Fig. 5.—Abnormal growth of callus round fibula.

cannot say, but were this the case the constant working of the broken ends may have had something to do with the unusual appearance.

INFLAMMATION IN BONE

A CHRONIC inflammation in an early stage—one of a few weeks' duration unaccompanied by abscess formation—will rarely give any *X*-ray indications. At most a thinning or absorption of mineral matter is noticeable.

Early periostitis.

In the case of an early chronic periostitis it is not uncommon for the *X*-ray appearances to be normal, while clinically the bone is much enlarged. In a few weeks this thickening will become visible as the mineral matter is deposited. Osteitis being generally accompanied by more or less periostitis, may therefore give its first evidence by the mineralisation of the swollen periosteum.

Periostitis.

Looking along the outline of the bone, this newly deposited mineral matter may be seen usually in lines running parallel with, but not touching, the shaft of the bone. Presumably there are cases of inflamed bone which quickly subside and leave no trace to the *X*-rays, but experience suggests such cases are rare. For example, a bone that has been struck sufficiently to cause a tender

spot lasting a week, yet not cracked or structurally damaged, may in a few weeks exhibit

FIG. 6.—Chronic periostitis of tibia and fibula. Observe lines of mineral matter parallel to shafts of bones.

layers of mineral matter in the periosteum covering the part which is absorbed again in a few more weeks. Such thickening and mineralisation of

FIG. 7.—Chronic periostitis of tibia. Observe line of newly-formed bone parallel to shaft on inner side.

FIG. 8.—Simple abscess just above epiphysial line of lower end of tibia. The general definition of the surrounding bone tissue would negative tubercle.

the periosteum over a bruised bone may suggest the callus of a fracture and that some fissure has been overlooked. It can usually be differentiated

FIG. 9.—Front view of Fig. 8.

Linear arrangement of newly-formed bone salts.

from callus by the linear arrangement of the bony layers as opposed to the spotty distribution of the bone salts in the latter (Figs. 6 and 7). Linear marks parallel with the shaft of a bone which presents clinically no other sign than increase in

FIG. 10.—Chronic osteitis. The upper portion of the bone is sclerotic and the disease is quiescent as evidenced by the great density. The lower portion shows the thinning due to the active inflammation. Midway is an abscess cavity with a sequestrum.

FIG. 11.—Small abscess cavity in shaft of tibia. Probably active and containing bone débris.

size, are strong presumptive evidence of inflammation of some duration. Such inflammation may have several causes, but as a fact which conclusively puts growth of a malignant nature out of

FIG. 12.—Results of chronic osteitis, probably healed. Old abscess cavities and much sclerotic change causing extreme density.

court it is highly important. One has in mind three occasions when this simple observation determined the diagnoses of three patients with enlarged shafts to their femurs, each of whom was supposed to be the victim of

Fig. 13.—Old abscess cavity in head of humerus; disease quiescent or extinct.

malignant disease. In one there was a definite history of traumatism—a kick on the thigh, but in the other two cases the cause of trouble was more obscure. It is not always so simple a matter to

FIG. 14.—Showing usual signs of chronic osteitis. Destruetive and reparative processes going on side by side; spindle-shaped piece of dead bone being exfoliated shown by arrow.

make a differential diagnosis between inflammatory and malignant condition as the case of which Figs. 36, 37, and 38 are the illustrations will prove in the chapter on growth in bone.

Differential diagnosis of growthand inflammation.

Later stages of bone inflammation.

Subsequently the subject of bone inflamed by other than simple causes will be dealt with, but for the present it will be better to follow

Fig. 15.—Chronic osteitis and sequestrum.

up the *X*-ray appearances of the later stages of bone inflammation.

Necrosis and abscess formation may with

advantage be considered here (Figs. 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 and 18).

The longer an inflammatory process proceeds the more easily may the thinning of the mineral

FIG. 16.—Necrosis of terminal phalanx of great toe, showing ragged appearance of the edges of the eroded bone.

matter and the excavations be recognised. Irregular hollows with ragged outlines are the rule in an acute stage, the bone disappearing in much the same way as a lump of sugar dissolves

FIG. 17.—Result of acute osteo-myelitis in young bone. The ulna has disappeared, but a new bone is growing in the old periosteum. In the meantime the radius has grown longer than the ulna.

(Fig. 16). The cavities forming at this stage, being filled with bone debris and mineral matter dissolved from the walls, are not so obvious or easily recognised as if they were filled with air

Fig. 18.—Sequestrum in first phalanx of second finger.

or even new growth of a soft nature, or a simple fluid; hence one must look very carefully for them (Fig. 11). In one's experience sequestra are not so frequently found, or at any rate so obvious as would be supposed. Several examples are, however, shown (Figs. 10, 14, 15 and 18).

Sequestra.

The inflammatory process may proceed to complete destruction of the bone and mere pulpiness remain, which to the rays will show as a greyish mass with little crumbs of dark material scattered through—particles of disintegrated bone. This appearance is rather rare in simple inflammatory

FIG. 19.—Root of tooth being eroded by unerupted tooth B.

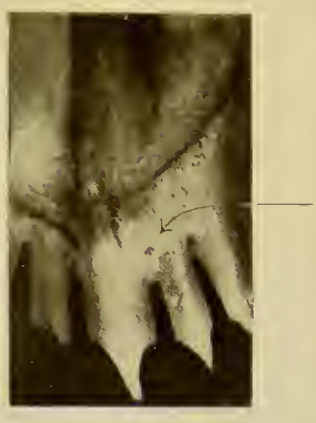

FIG. 20.—Clear area indicating absorption of root of central incisor. All the front teeth are crowns fitted to stumps.

condition, and is mostly seen in the chronic destructive process of tubercle.

Resolution of inflammation.

In the event of an acute, subacute, or chronic inflammatory process resolving, the changes in effect are slow but sure to the rays. There is a gradual clearing of the image from the absorption of fluids, a general tendency for the bone to become more opaque from the redistribution of mineral matter, gradual intensification of the bone shadow (evidently sclerotic changes and a depositing of extra bony material where the

Sclerotic changes.

mechanical strains of the limb demand support). A bone recovering from a severe inflammatory disorder will therefore show many dark lines and patches which, contrasting with the rest, will give a very variegated appearance. Layers of new bone

FIG. 21.—Showing light normal area around lower unerupted wisdom.

formation in the periosteum will accompany this state of affairs and add to the irregularity of the picture (Fig. 12.) Old cavities will be easily recognisable, as those are very slow to get filled with *X*-ray opaque material, and one has seen such cavities many years after recovery (Fig. 13).

Where resolution has been delayed, or chronic suppuration has supervened on an acute osteitis, sclerotic changes may be seen, accompanied by disintegration of other portions of the bone, or one cavity may continue to discharge pus while surrounding portions of the bone show signs of recovery (Fig 14). Occasionally in such cases the cavity is injected with some *X*-ray opaque material such as bismuth in emulsion. This method is one that Mr. Charters Symonds uses with much success. The bismuth emulsion is injected into the cavity with a syringe, and under slight pressure finds its way into all the ramifications of the abscess and the extent of the cavity is thus very satisfactorily shown.

Injection of bismuth into bone cavities.

Whilst discussing the radiographic appearances of inflammatory conditions of bone, special remark should be made of dental conditions. The carious tooth will of course give its characteristic shadow to the rays, but the dental mirror is obviously more satisfactory for diagnostic purposes. However, there is often much conjecture as to the health or otherwise of the portion of a tooth which cannot be seen by ordinary methods. A simple example is abscess round the root of a tooth. This makes itself abundantly evident by a clear area—caused more by the absorption of mineral matter than by actual cavity (Figs. 19 and 20). In cases where small pieces of root have been left behind after extraction these may usually be seen lying in an apparent

Dental conditions.

Abscess at root.

FIG. 22.—Normal appearance of teeth. Note the lower unerupted wisdom in its surrounding clear area.

halo—the surrounding area of demineralised bone tissue. Around an unerupted tooth (Figs. 21 and 22) a light area is also present, but this is so shapely and clearly outlined that once seen it could never be mistaken for the abnormal and irregular patch surrounding a septic stump. Larger abscesses in the jaw do not differ materially in their *X*-ray appearance from bone abscesses elsewhere.

TUBERCULAR DISEASE

Thinning of bone tissue in tubercle.

TUBERCLE in bone manifests itself chiefly by undue transparency. Being a disease in which malnutrition is much in evidence, it is no uncommon thing to find all the bones of a tubercular subject less opaque than normal, although no tubercular bone disease is present. At the site of a bony lesion all grades of increased transparency are observable from the slight change of general malnutrition to the extensive ones of rarefaction, necrosis or cavity formation.

Disappointing *X*-ray appearance of tubercle.

When the lesion is in the neighbourhood of a joint additional changes are observable. In an early stage when the synovial membrane alone is affected the appearance to the rays is what one can best describe as disappointing. Instead of the clear outlining of the bones and their cancellated structure, a fluffy effect is seen, the outline being blurred and the cancellus tissue difficult of detection. The unskilled will observe "what a pity the photograph is not clearer," and one has learnt to regard this criticism as a strong confirmation of a diagnosis of

tubercular disease in joints (as well as in certain other situations spoken of later). This blurring is due to fluid in part, but also to thickened synovial membrane, the fluid in the case of tubercle being much less than in a simple acute arthritis. An acute or subacute arthritis may show a greater degree of blurring than early tubercle, and unless clinical evidence is very definite a simple and a tubercular arthritis may be confounded. It is not often that the mistake is made. A careful examination of the surrounding bone tissue will help to confirm or disprove a suspicion of tubercle. On the other hand, I once examined a child's knee much swollen and with clinical evidence pointing to subacute arthritis after traumatism, in which the bony surfaces were already invaded with tubercle and the complaint really one of tubercular arthritis of a rapid nature. In this case the rays certainly superseded other methods of diagnosis, and on their evidence the joint was excised.

The "fluffy" joint.

It would be incorrect to say that all blurring in the neighbourhood of joints was significant of tubercle, as simple fluid and blood may give much the same effect but excluding these conditions; which are usually easy of detection, the fluffy joint nearly always means tubercle in an early to a late stage (Fig. 23). For example, if a child complaining of pain in a hip joint, or in some way attracting the attention of the medical attendant and causing him to suspect tubercular disease in this region, is

FIG. 23.—Active tubercle in tursus, an early stage

examined, and one hip joint shows as clearly and brightly as the other, the evidence is powerfully against tubercle, and if the joint be examined again

FIG. 24.—Hip joint in an active tubercular state. Note the thinning of the bone, and the general unsatisfactory appearance from a photographic standpoint.

in a few weeks with the same result the cause of pain, limping or what not, must be attributed to something else.

The converse, of course, holds good, and the careful surgeon will never omit to examine a young person with the rays who complains of symptoms which are in any way compatible with hip disease (Fig. 24). In this connection I might

FIG. 25.—Congenital dislocation of right hip.

mention that congenital dislocation of the hip is occasionally first discovered under such conditions, and can recall at least three occasions where the most careful of surgeons have completely overlooked this condition (Fig. 25).

There is no question that the symptoms of a congenital hip are sometimes so obscure that all ordinary methods fail to detect its presence.

The blurred or fluffy effect seen in a tubercular joint is also observable in other situations; thus a bone shaft affected by tubercle in an early stage gives a very similar effect. No doubt, as before suggested, the fluid in the joint in a great measure explains the obliteration of the outlines of the joint; but it is certain that contrast and definition are further marred by the absorption of mineral matter in the bone structure rendering it less opaque. Whatever the cause, a tubercular inflammation in bone seriously impairs the photographic effect.

If a piece of decalcified bone is examined with the *X*-rays, the effect powerfully suggests a bone affected by tubercle or in the neighbourhood of a tubercular lesion. On the other hand, the dried bone has much in common with the *X*-ray appearance of osteo-arthritis.

In a later stage of tubercle in a joint, the ulceration of the joint surfaces of the bones gives rise to irregularity in their outlining; a more or less ragged appearance is thus presented. This ragged appearance is due to absorption of the mineral matter rather than actual erosions. After this, caries with accompanying rarefaction and tissue destruction will markedly affect the transparency of the bony material forming the joints. Pus

may be present at this stage, and will require consideration.

It is a rule, and a good rule to bear in mind, so constant that one might almost call it a law, that radiograms of tubercular disease in bones and joints are always disappointing from a pictorial point of view, while osteo-arthritic conditions give rise to photographic effects of unnatural brilliancy and prettiness.

Contrast of tubercle with osteo-arthritis.

A tubercular cavity filled with pus may appear as a light area, but not so clearly outlined as an old cavity, such as is found in a case of healed caries. The explanation is no doubt simple. Pus in a recent bone cavity is accompanied by the bone debris that has been accumulated in the interior of the cavity, or at any rate by the mineral matter from the dissolved bone, and hence is much more opaque to the *X*-rays than a simple fluid or medullary substance.

Added to this, the bony material forming the walls of a tubercular cavity is poor in mineral matter, and consequently more than usually transparent to the rays. Hence the contrast is very slight. A cavity left after a necrosis has subsided will be more decided in outline because of the sclerotic changes in its walls, which usually become excessively mineralised and strengthened by extra bony layers (Fig. 10).

The outline of a cavity the result of active tubercular disease is irregular and eroded, whereas the old cavity is much smoother in outline.

It is superfluous to point out the practical importance of these distinctions where the question of active or quiescent disease is being considered.

When a tubercular joint has passed into the pulpy stage, all the above-mentioned photographi-

FIG. 26.—Result of old tubercle. Clearness of bony tissue suggests disease quiescent or extinct.

cally disappointing appearances are exaggerated, the opacity of the bone becoming diminished to the degree of extinction and the fluffy appearance spreading and obscuring any outlines formerly present, until it may become next to impossible to

see upon the screen the slightest trace of bony structure. Sometimes, however, the rays will reveal at this stage a ghostly outline of the bones. The displacement which takes place in joints affected with

FIG. 27.—Result of tubercular disease between second and third lumbar vertebrae. The clearness and density of the bone conclusively proves the condition to be cured.

tubercle is usually discernible with *X*-rays, but in the hip, owing to the fact that radiograms in this region are mostly unsatisfactory, a slight displacement of the femoral head is often the first radiographic indication of tubercular disease, and

in this connection the diagnostic line which I have described upon several occasions will be found of great value. I append a short description. Any interference with the symmetry of this line should be regarded with apprehension.

FIG. 28.—A normal hip joint showing the diagnostic line.

This line in all positions of the joint, *i.e.*, abduction, adduction, etc., of the femur, is the same, an unbroken arch formed by the top of the obturator foramen, and the inner side of the femoral neck. Imagination must connect these two lines before a perfect arch is formed, but a glance at Fig. 28 will

show that this line is a reality and not solely imaginative.

As before stated, in all positions of the femur this arch can be detected.

There are many lesions of the hip joint which will disturb this line. Congenital dislocation is a good example.

In Figs. 25 and 26 this broken arch is well shown.

It is often said that the distortion of the rays makes appearances which resemble displacements in the hip region. To some people distortion may be deceptive, but no amount of distortion will affect this line. Anyone seeing a skiagram of a hip for the first time, and taking into consideration the intactness or otherwise of this line, could say with certainty whether displacement were present or not.

Another point is this, that radiograms of the hip region are very often most unsatisfactory on account of the thickness and density of the part. Few radiograms, however bad, will fail to show the femoral neck and the obturator foramen. Hence in this respect the diagnosis will be as correct with a very poor skiagram as with one in which there is the utmost detail.

OSTEO-ARTHRITIS.

It would seem suitable to point out a few of the important signs given by the *X*-rays in osteo-arthritis as opposed to those found in a tubercular joint. Being among the first, if not the first, to point out the curious *X*-ray appearances of rheumatoid and osteo-arthritis to the *X*-rays (*Clinical Journal*, May 29th, 1901), my attention has been drawn to the subject for many years, and though there is "a look" about an osteo-arthritic joint which to the experienced eye is unmistakable, it is with difficulty that I am able to determine upon facts which will serve as guides to the diagnostician. Tubercle is the most likely disease to be mistaken for osteo-arthritis.

In the first place, the characteristic which these two diseases have in common—a thinning of the mineral matter—is, paradoxically, the most important factor in their differentiation.

The thinning of the mineral matter in the bones of tubercular arthritis is of such a general character that perhaps the best simile would be a

chalk drawing very much "rubbed out"—a blurred faint image. Hence a characteristic radiogram of a tubercular joint is a disappointing one from a pictorial standpoint.

"Mr. So-and-so would be glad if you could get him a clearer radiogram of such-and-such a joint" has been said to me so often in relation to tubercle that I am bound to admit my indebtedness to Mr. So-and-so for pointing out an indisputable fact—which he has failed to recognise himself—that the general *X*-ray characteristic of tubercular joint disease is want of contrast and want of detail.

Differential diagnosis.

Turning to rheumatoid and osteo-arthritis (I cannot find any *X*-ray line of demarcation for these diseases, and so will speak of them as if varieties of the same), a thinning mineral matter is most noticeable, but of a totally different nature from a tubercular thinning.

Certain portions only of the bone are thinned, and in such a way as to produce an outlined effect, not only of the bones, but of their internal structure. I would suggest, as simile, the skeleton leaf. The result of this special form of absorption of the mineral matter is to increase detail and strengthen the outline of the photographic image (Figs. 29 and 30). In other words, the radiogram is, from a pictorial aspect, prettier than normal.

To summarise, the tubercular joint gives a radiogram of a disappointing fluffy and ill-defined

FIG. 29.—Rheumatoid arthritis in active stage. Note the characteristic thinning and the emphasising of the cancellous tissue.

FIG. 30.—Rheumatoid arthritis in active stage.

appearance, while the osteo-arthritic joint gives a particularly brilliant one. I cannot say that every case will present these characteristics to such a marked degree that no one could err in a diagnosis. But I will confidently affirm that in a greater or lesser degree they are always present.

Though I am making a rule to confine my remarks to the general characteristics of bone disease, I venture here to break this rule by giving details of a case. I do not publish the radiograms because they are not entirely typical, and I fear in reproduction they might appear in a misleading form.

Dr. Winslow Hall has most kindly furnished most of the details which I append.

On June 2nd, 1908, I was called to see a patient who was suffering from a swollen knee. Patient, elderly unmarried lady. Family history, markedly tubercular.

Oct. 4th—Slipped on fallen leaf, and fell on her knee.

Oct. 5th–7th.—Rest.

Oct. 8th–26th.—At work (teaching).

Oct. 26th to Nov. 10th.—Rest and "Bier" treatment.

Nov. 19th to Dec. 16th.—At work wearing bandage. Calmette's test gave positive result.

Dec. 19th.—Seen by Surgeon "A."

Dec. 23rd.—Opsonic indices before Bier's bandages 1·03. After two hours, 1·20.

1909, Feb. 27th.—Bier's bandages two hours once a week.

March 12.—Fluctuation in joint.

April 7th.—"A" sees patient, advises amputation, but tuberculin to be tried first.

April 9th to May 21st.—Four injections of tuberculin fortnightly.

June 2nd.—*X*-rays and diagnosis of osteo-arthritis.

June 11th.—Opsonic indices before Bier's bandages 1·08. After, 1·01.

June 26th.—Another surgeon, hereinafter called "B," advised operation—"politeal space full of pus."

June 29th.—Aspirated fluid examined. No pus, no organisms.

Case then seen by another medical man, "C," a relation, who agreed in rejecting diagnosis of tubercle and amputation. Treatment by Scott's dressing, and pot. iod. in large doses, then Thomas' knee splint, then crutches. Steady improvement until 1909, when walking on own feet, wearing a poroplastic case round knee, and using stick and crutch.

July–October.—Away in Ireland; on return amputation demanded by patient, and performed by "A."

I make a few extracts from a letter sent me on October 7th, 1909, by Dr. Winslow Hall:—

"DEAR SIR,

"Probably you have not forgotten that knee of Miss ——, which you radiographed for me last summer. The sequel will interest you."

Here follow a few details unimportant to the subject in hand, and Dr. Winslow Hall continues :

"When she returned, he ('C') wrote to me strongly urging amputation, on account of her confirmed and increasing invalidism. She herself desired amputation, and her relatives also urged it.

"I pointed out that the joint had been steadily improving, and that a useful limb could be counted on in time. I maintained that the limb, as a limb, did not require removal, but that possibly she might require removal from her limb.

"'A' was asked to see her again. He promptly advised amputation. Accordingly he did a supra-condylar amputation yesterday. The joint showed no sign of tubercular disease, but was typically osteo-arthritic with very thick growing ligaments and considerable eburnation of cartilage and bone.

"If you care to see the specimen, you will find it at X, Y, Z Hospital. You see you were quite right. Other comment is needless."

Looking back over the history of this case, certain facts stand out vividly. The great surgical opinions, so positive and so wrong ; the convincing circumstantial evidence in favour of tubercle ; the whole so biasing to the newcomer that it needed much courage and faith to uphold what seemed an

impossible theory, the theory of osteo-arthritis as divulged by the *X*-rays; the instinctive leaning towards this theory of the patient's medical

FIG. 31.—Osteo-arthritis of knee, showing the typical outlining and fine definition.

attendant, Dr. Winslow Hall, before and after *X*-ray examination.

I have recently read Dr. Llewellyn Jones' able book on "Arthritis Deformans," and I would

FIG. 32.—Osteo-arthritis old and quiescent. Bone fairly healthy. Much lipping.

FIG. 33.—Atrophic change in bone caused possibly by old fracture of patellæ. The change is not unlike osteo-arthritis in many respects.

No line of demarcation between osteo and rheumatoid arthritis.

hesitate to add to the literature of this subject which is already so extensive and complicated. So much confusion would appear to exist in the differential diagnosis of osteo and rheumatoid arthritis that it may be of interest to state as the outcome of one's *X*-ray experience, no line of demarcation exists, nor does one find any *X*-ray evidence to support the idea that there are two definite and dissimilar diseases.

Whether this condition is one disease with a multiplicity of clinical and physical signs or whether a multiplicity of diseases, the rays do not seem able to determine, but one would be inclined to think that there is one general *X*-ray characteristic, that of the peculiar thinning above described, and two particular *X*-ray characteristics, that of a very marked thinning in certain regions as in the phalangeal joints of the hand (see Figs. 29 and 30), and that of additional bony tissue causing lipping and hard outlining (Fig. 32).

Thinning usually means active disease.

Unquestionably the former, the marked local thinning as in all bone disease, indicates a rapid and active process or disease (Fig. 31), and the latter a very old-standing and usually quiescent condition (Fig. 32). By quiescent I mean no active inflammatory process though mechanical conditions may be getting progressively worse for mechanical reasons.

I show Fig. 32 as what I consider a typical example of this latter condition.

FIG. 34.—Atrophic changes in bone of amputation stump.

Other atrophic changes in bone are often observable round about old badly united or ununited fractures. Fig. 33 shows this condition, which would certainly in my opinion negative any operation on these bones. They would be too friable in their present condition.

Friable bone.

In Fig. 34 atrophic changes of a local nature are taking place in an amputation stump.

GROWTH IN BONE

NON-MALIGNANT.

These are either cystic in nature, simple or parasitic, and evident to the rays as hollow cavities of regular outline, unlike the usually ragged appearance of abscess cavity, or they are over-growths of the normal tissues forming bone.

Exostosis is an example of the latter, and one of the easiest of all abnormal bone conditions to diagnose. These out-growths usually appear as hook-like processes, and when such a hooked protrusion from the bone is noticed in a region which is a common site of exostosis, no trouble will be found in deciding the nature of the disease. Exostosis.

This apparent hook, which merely indicates the arrangement of the bone salts and does not necessarily imply a real hooked process capable of being felt externally, invariably turns away from the epiphysial line nearest to which it grows (Figs. 35 and 36).

There is, however, an occasional specimen of large exostosis which might possibly suggest a sarcoma of slow growth—that is, one that is ossifying as it grows (Fig. 37). Usually the clinical signs are

FIG. 35.—Typical appearance of exostosis. The hook turns away from the epiphysial line.

such that no question arises as to its innocence, but should there be any doubt a careful examination of the radiographic appearance will decide.

FIG. 36.—Exostosis of head of fibula accompanied by some enlargement of the head of that bone. The possibility of malignant disease had to be considered in this case, and the *X*-rays proved the innocence of the condition. The hook-like process turning away from the end of the bone is very characteristic of exostosis.

FIG. 37.—Exostosis simulating clinically periosteal sarcoma of upper end of humerus.

FIG. 38.—Exostosis of lower end of femur from a case of multiple exostosis.

FIG. 39.—Sarcoma of lower end of femur. The new bone deposited around shaft has an irregular spotty appearance totally different from the regular bony layers seen in chronic periostitis. (Mr. Mower White's case.)

FIG. 40.—Sarcoma. front view of figure.
(Mr. Mower White's case.)

In exostosis the growth is slow and regular, and the resulting radiogram shows this to perfection, just as the section of a tree trunk shows by its rings the uniformity and regularity of its growth (Fig. 38). In malignancy the ossification takes place in a ragged and irregular way, and the effect is spotted and not uniform. It is often that small patches are breaking down, and these, appearing lighter than surrounding parts, add to the heterogeneous arrangement of the picture.

Malignancy.

This irregularity is in every form of bone malignancy a prominent feature.

I would here pause to consider a case of endosteal sarcoma where a disregard of this spotty, irregular appearance led me to suggest that the condition was a simple one. Mr. Mower White, who had the case under his care, fortunately did not agree, and he removed the limb with complete success. This case made a great impression on me, and I hope it has been the means of forcing me to notice the really vast difference in the radiographic effects between simple inflammatory conditions and malignancy.

Radiograms of this case before operation are here shown (Figs. 39 and 40), as well as one taken of the bone above just after removal (Fig. 41). In the latter case the irregular blotchy nature is more easily recognisable.

The disease was sarcoma, and all the bony substance was involved. There was much ossifica-

FIG. 41.—Sarcoma, the actual bone from case shown in Figs. 7 and 8. (Mr. Mower White's case.)

FIG. 42.—Endosteal sarcoma of rapid growth diagnosed as greenstick fracture previous to *X*-ray examination. No signs of ossification.

FIG. 43.—Endosteal sarcoma in child. Note the irregular spotty appearance.

tion going on, accompanied by a breaking-down process.

If this appearance were committed to memory it would be found a landmark when investigating bone disease. As disappointment in photographic result means tubercle, and brilliancy in contrast means osteo-arthritis, so gross irregularity in the substance of a bony growth means malignancy. Rules are but rules and subject to exceptions, but as rules these observations are of value.

An endosteal malignant growth is usually easier to detect than a periosteal. The obviously rapid expansion of the overlying bony shell is apparent, and could not be mistaken for an inflammatory condition. The medullary cavity disappears, and the only bony material is that on the outside of the swelling. Fig. 42 shows an endosteal sarcoma of radius.

This case was sent to me as a greenstick fracture of radius with much callus formation. Comment is superfluous.

OSTEO-MALACIA

TYPICAL examples of this disease are shown in Figs. 44 and 45; here may be seen the replacement of the medullary tissue by *X*-ray transparent material, and the general rarefaction and absorption; the centrifugal method of progress, and the immunity (more or less) of the compact tissue.

FIG. 44.—Osteo-malacia, showing the rarefaction accompanied by new deposit of bone in neighbourhood of compact tissue. The bone would appear to be strong on account of the density of the mineral matter.

FIG. 45.—Side view of Fig. 44, showing where disease leaves off and fairly normal bone begins.

FIG. 46.—Ossified loose body in knee-joint. The lower margin of the patella is suffering from pressure, and there is evidence of absorption of mineral matter.